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EXPLOSIONS IN COAL MINES CAUSED BY SMOKING

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BY

D. HARRINGTON AND D. J. PARKER

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

EXPLOSIONS IN COAL MINES CAUSED BY SMOKING[1]

By D. Harrington[2] and D. J. Parker[3]

INTRODUCTION

More or less unconsciously and from sheer force of habit human beings do many things they probably would not do if the possible consequences of their acts were fully recognized and appreciated. Such carelessness ordinarily could be condoned if human life were not at stake, but it is difficult to understand why intelligent men engaged in the hazardous occupation of mining indulge with the utmost indifference in some habit or continue some custom in violation of State laws and company regulations and under circumstances that may jeopardize not only their own lives but those of scores, even of hundreds, of their fellow workers as well. The old adage that stolen sweets are the best may or may not have some foundation, but when applied to the practice of smoking surreptitiously in a coal mine, more especially a gassy mine, it is without even remote justification.

Although a relatively harmless habit in the proper environment, smoking has been the cause or suspected cause of many gas explosions and black-powder ignitions and has resulted in numerous instances of bodily injury, loss of life, and destruction of property. Likewise, many fires in both coal and metal mines, causing loss of life, have been started by smoking.

The apparent seriousness of the situation, as evidenced by the occurrence during the first 7 months of this year (1940) of at least three gas ignitions, possibly as a result of smoking, justifies bringing this matter to the attention of employers and employees alike at this time.

BRIEF REVIEW[4]

As far back as 1839 and up to and including 1937, at least 678 explosions, which resulted in the death of 5,429 persons and were caused by open lights or smoking, are known to have occurred in the coal mines of the

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7141."

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4/ Harrington, D., Forbes, J. J., and Fene, W.J., Thousands Killed by Coal-Mine Explosions in the United States: Bureau of Mines Inf. Circ. 7004, 1938, 15 pp.

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United States. Owing to the identical hazards involved, ignition from either cause has been the greatest single source of explosions, having been responsible for 23.7 percent of all those of which record was available up to 1933.

Of a total of 130 explosions in Alabama mines 76.9 percent have been caused by open lights and smoking. Pennsylvania anthracite mines have experienced 90 such explosions (7.3 percent of the total for such mines), while Colorado, Indiana, West Virginia, and Pennsylvania bituminous mines also have had a large number of explosions so caused. Open lights and smoking have been the cause of ignition in 39.1 percent of the fatalities due to explosions as listed in these records; however, during the 7-year period, 1931 to 1937, fatalities from explosions from these causes have been reduced to about 23 percent.

Although information as to the number of explosions actually caused by smoking compared with those caused by open lights is not available, it is definitely emphasized that for more than 100 years smoking and open lights have been the important causes of disastrous mine explosions.

TEMPERATURE OF BURNING TOBACCO[5/]

From time to time the question has been raised whether burning tobacco in the form of cigars and cigarettes or in pipes will ignite methane or firedamp. Since a flame (which readily ignites methane), whether from a match or patent lighter, is generally used by smokers, the question seems to be somewhat pointless and irrelevant and may lead one to believe that once the tobacco is ignited in fresh air, away from the working face, a leisurely stroll may be taken back to the face or other possible gassy place, where a smoke may be enjoyed with complacency, even in a possibly inflammable or explosive gas-air mixture.

Exhaustive tests by the Departments of Commerce and Agriculture in 1916 proved that a burning cigar develops a temperature during puffs of 1,500° to 1,700°F., and between puffs the temperature ranges from 1,100° to 1,500°F. The temperature necessary to ignite methane ranges from 1,000° to 1,380°F. Based upon the assumption that temperatures developed by burning cigarettes and in pipes are comparable to those produced by a burning cigar, the conclusion is reasonable and obvious that burning tobacco, regardless of the method of use, is likely to ignite methane, though many "old timers" are inclined to dispute the correctness of this conclusion.

The foregoing is a little surprising because preliminary tests in the Bureau of Mines laboratory about 25 years ago indicated that a glowing cigarette would not ignite methane until the methane-air mixture attained a velocity of about 1,000 linear feet per minute or more. This appears to be

5/ Sligh, T. S., Jr. (assistant physicist, National Bureau of Standards), and Kraybill, Henry R. (assistant physiologist, U.S. Department of Agriculture), Temperature of a Burning Cigar: Am. Inst. Min. Met. Eng., vol. on Pyrometry, 1920, p. 645.

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beside the issue, as common sense and not the air velocity should determine the safest course to pursue. However, it is well to realize that taking a lighted cigarette, cigar, or pipe into an explosive mixture of methane and air is extremely hazardous, and the practice is likely to cause an ignition; anyone so doing should, if he survives, be prosecuted to the fullest extent of the law.

SUMMARY OF CASES

In every instance of gas ignitions with resultant explosions, especially those of great violence, the exact cause cannot be proved beyond a reasonable doubt. This applies particularly to ignitions that may have been caused by smoking because the guilty person is either killed or, if he does survive, generally fails to admit the true facts or, in some instances, seeks immunity from giving information on the ground that the law does not require him to give self-incriminating evidence. However, a few instances are cited in which direct evidence was preponderant and conclusive or the circumstantial evidence was such that the probable cause of gas ignitions was smoking.

1. An explosion occurred on October 30, 1926, in the rock tunnel of a large mine and resulted in the death of nine men. The tunnel, which had been driven to intersect a certain vein of coal, was 12 feet wide and had a line brattice its entire length; the return side, which was also the trolley-locomotive haulage side, was 10 feet wide, and the intake was only 2 feet wide. There was an electrically driven booster fan on the intake side near the inby end of the tunnel. Methane was found by the fire boss on the morning of the explosion in workings near the tunnel. The booster fan was started to clear the section of methane before the men entered; the gas, moved to a place where the men were waiting, was ignited by a cigarette being smoked by one of the men.

The direction of forces clearly indicated that the explosion originated at the point where the nine men (who were killed) were congregated. Cigarettes, books of cigarette papers, sacks of tobacco, burned match stems, and unlighted matches were found at this point.

Although, in general, the company provided some up-to-date, safe equipment and enforced a number of precautionary measures the following dangerous mining practices were in effect: The use of one entry system to ventilate gassy workings; having the men in the immediate region while methane accumulations were being moved; and the use of booster fans with open electric equipment close to gassy workings. The fact that miners smoked in a closed-light mine, known to be gassy, and while a gas accumulation was being moved, showed a deplorable lack of judgment on the part of the smokers and of discipline on the part of the mine officials.

2. An explosion occurred in a mine on June 6, 1924, causing the death of 14 men and slight injury to 6 others. A body of gas was allowed to accumulate while a door was being removed and replaced. When the new door was placed the gas was moved along the return airway and was ignited by a miner who attempted to light a cigarette. Near what was evidently

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the origin of the explosion, burned matches and several cigarettes were found near the body of a miner; in nearby localities cigarettes, pipes, and matches were found in the pockets of men's jumpers.

As this was an extremely gassy mine (liberating more than 4-1/2 million cubic feet of methane every 24 hours) too many precautions could not have been taken. From the amount of smoking material found it was apparent that discipline was not enforced, at least as to smoking. This was another one of numerous explosions that resulted while a body of gas was being moved and is evidence that such practice is extremely dangerous when the shift is in the mine, whether the mine is working with open or closed lights, permissible or nonpermissible equipment.

3. A mine explosion that occurred on July 3, 1926, resulted in the death of seven men and injury to eight others. Pillars were being pulled in the section of the mine where the explosion occurred, and on the morning of July 3 there was evidence of a squeeze along the pillar line. The men were removed to another part of this section until the fall came; this occurred later in the day, and an accumulation of gas that probably had been liberated by the fall was forced into the section where men were working and ignited.

The State mine inspectors who made the investigation were unable to determine the source of ignition of the gas, but subsequent information indicated that it probably was a defective flame safety lamp, although smoking was a strongly suspected cause of ignition.

4. On July 14, 1932, a gas ignition in a mine caused third-degree burns to three men, two of whom died. The ignition occurred while a man was cutting a hitch in the roof for a jack prop. The hitch was about 6 inches from a crack in the roof, which afterward was found to be emitting gas. No other work was being done at the moment in this place. For some time a spark from a pick was alleged to be the cause of the ignition, but by a process of elimination the cause was finally determined to be smoking or smoking materials.

This mine was considered gassy; fire bosses were employed, and permissible electric cap lamps and flame safety lamps were used exclusively. The coal was shot with permissible explosive, fired electrically, but unquestionably some of the men smoked, notwithstanding rules against such practice. Even if there had been no rules against smoking, common sense and a decent regard for their own safety as well as for the lives of their coworkers should have prevented the workers from smoking while in this definitely gassy mine.

5. A coal-dust explosion initiated by the ignition of a body of gas occurred in the Linton mine of the Linton Coal Co., Chai, New Zealand, on November 15, 1929, resulting in the death of three men. The mine had been reported clear of gas on the morning the accident occurred, but a body of gas accumulated and was ignited by a man who had been left alone by his coworkers. This man was known to be an habitual cigarette smoker, and

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matches and cigarette papers were found in his clothing after the explosion. This man, who was badly burned, was accused of igniting the gas, although it was admitted that the source of ignition was not positively determined. The use of matches or smoking materials was against the law, as the mine was on a closed-light basis.

This occurrence indicates that the mining laws of New Zealand are violated (at least in this respect) very much as they are in the United States; this has been confirmed by the fact that in a New Zealand coal mine 11 persons were killed in 1939 by a fire said to have been caused by smoking.

6. The report on the Bartley, W.Va.,[6/] mine explosion, which occurred on January 10, 1940, with 91 fatalities, states that although smoking was prohibited in this mine the ignition may have been caused by smoking or matches. That two cigarettes were found in a miner's jacket strengthened this belief; however, no matches were found. On the other hand, the miners were searched daily for matches and smokers' articles on the surface before each shift entered the mine. The authors of the report were unable to learn of any instance when anyone had been detected smoking in the mine; and while smoking could have caused this explosion, they were exceedingly doubtful about it.

That[7/] smoking was "ruled out" as a possible cause of the original ignition was unfortunate, as this conclusion is definitely supported by the fact that in an explosion on March 1, 1940, in Virginia (only a few miles from the Bartley mine), a coal-mine worker was burned to death when he ignited a body of gas while smoking. The fact that the report shows that on the day of the disaster a man smuggled cigarettes into the Bartley mine with its desperately hazardous gassy conditions (certainly known to all of its employees) indicates that that man, and possibly others as well, probably smoked in the mine on the day of the explosion; and, if smoking was done at all, the smoker most probably would have gone to some out-of-the-way place to do it, such as the gob region, where gas accumulations were most likely to be found. There is good reason for strong suspicion that smoking was involved in this disaster, although neither matches nor burned cigarettes were found, and no evidence was obtained from bosses or workers that the no-smoking rule was disobeyed either habitually or occasionally.

7. A local gas explosion occurred in a mine on March 1, 1940, and resulted in the death of one man from burns.

Because no methane had been found in this mine before the explosion the State had rated it as nongassy. The day after the explosion, however, 0.20 to 1.40 percent of methane was found in the area affected by the explosion. Permissible electric cap lamps were used. The coal was shot with

6/ Ankeny, M. J., Gleim, E. J., McCall, M.C., and Owings, C.W., Final Report on a Gas and Dust Explosion, January 10, 1940, in Mine No. 1 of the Pond Creek Pocahontas Co., Bartley, McDowell County, W. Va.: Bureau of Mines rept., 52 pp.

7/ See footnote 5, p. 2.

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a permissible explosive, fired electrically, and 60 percent straight dynamite was used for blasting rock.

Without a doubt the gas was ignited by the victim when he attempted to light a cigarette. Cigarettes in a tin container were found alongside the body. Smoking was not prohibited in this mine; but, whether it was or was not, the results are the same where explosive gas is present, and if it was not prohibited, it certainly should have been.

8. A man was burned fatally and two others slightly in a mine on November 14, 1939, when about half a keg of black blasting powder (granular form) exploded prematurely. At the time of the accident the victim was preparing a shot of black powder at a shooting truck about 12 feet from the face that was to be shot. He filled his pipe with tobacco and left the half-filled can on the truck. When he attempted to light his pipe, a spark from the match head flew off and ignited the powder, which caused such severe burns that death resulted in 25 hours. After the accident, the man ran about 50 feet, where he was stopped when he struck a timber; his pipe, freshly charged with tobacco and with the stem still wet, was found at this point.

The damp condition of the place in which the ignition occurred probably prevented an extensive coal-dust explosion that would have involved the lives of the 25 men in the mine at the time. The use of black powder is extremely hazardous under the safest possible conditions, but when the hazards incident to its use are supplemented and multiplied by those from smoking or open lights disaster is inevitable.

9. In a 1938 report[8/] a British coal-mine inspector stated that 5 lives were lost and injuries were inflicted on 21 persons in Scottish mines. The most serious accident caused the loss of four lives and injured seven workers. It occurred in a safety-lamp area of an Ayrshire colliery where permitted explosives, fired electrically, were used for the brushings and for the comparatively few shots in the coal. Electric cap lamps as well as a number of detector flame safety lamps were carried by the miners, and the firemen carried cap lamps in addition to their safety lamps. The men were searched at the fireman's station by the fireman of the shift, who descended into the mine immediately before the men at the beginning of each shift, and there was evidence that some men were searched on the shift in question.

At the inquiry a formal verdict was returned. As stated in Government Inspector Ashley's report, examination of the pockets of two of the deceased men revealed burned matches in both and an unlighted cigarette in one. A partly smoked cigarette was found below ground in the pocket of a waistcoat, and a burned match was found lying on the floor of the working place. There was no direct proof that any of the men had smoked, but the inspector considers that the only possible conclusion is that the igniting cause was

8/ Science and Art of Mining; Accidents and Their Prevention; The Problem of Explosions; Smoking Under Suspicion: London, vol. 50, April 6, 1940, p. 314.

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"smoking." Neither the examination for firedamp nor the searching of the men can have been very thorough.

10. On June 18, 1940, a local gas explosion occurred in a mine and resulted in serious but not fatal burns to one man.

This mine is classed as gassy by the State. Permissible electric cap lamps and magnetically locked permissible flame safety lamps are used exclusively. The coal is shot with permissible explosives and fired by electric detonators, clay stemming being used.

An entry and five rooms turned therefrom were driven to convert this area into a sump. The dams were so situated that the water impounded would reach the roof, thereby shutting off circulation of air inby before it had risen to the top of the dams. Presumably this condition prevailed several hours before the explosion.

For reasons unknown the injured man went to the outby face of one dam and while there the ignition occurred. There was no violence, and another man working about 150 feet outby was not injured. This man stated that gas was burning as it came through the hole in the dam, and that he closed the iron manhole door, and when it was opened several minutes later the flame had been extinguished. On his arrival about 10 minutes after the occurrence the mine foreman found tobacco and a cigarette paper floating on the water at the dam face; the obvious conclusion is that the ignition resulted from smoking by the injured man, and it is understood that later he confessed.

11. A gas explosion in a mine on July 13, 1940, killed two men and injured four others, one of them seriously.

The explosion occurred in one of three main parallel entries in a new development about 1,100 feet from the main portal of the mine. There were 23 men in the mine at the time; 17 escaped without injury. The three entries affected are ventilated by blower fans and tubing, the fans being set up in fresh air at a point where shortly after the explosion about 8,200 cubic feet of air per minute was passing.

The explosion, which was local, was confined to the three main entries and originated at the face of No. 2 main entry about 125 feet inby the last break-through. Evidently it was caused by one of the two men smoking while engaged in painting center lines in the place.

Because the mine was considered "slightly" gassy closed lights were used and smoking was prohibited. When the two bodies were recovered a cigarette, still moist at one end and slightly charred at the other, together with a burned match were found near one of the bodies. In addition, an empty match box and matches were found strewn about in the place.

The four persons injured were working in the last break-through about 175 feet outby the point where the explosion originated. The mine was partly rock-dusted and rather damp, and this probably prevented coal dust from entering into the explosion.

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Although two men were killed in this mine on July 13, 1940, as a result of smoking, three men with matches and smoking materials on their persons were apprehended in the same mine between July 20 and 29, 1940. They were prosecuted by the State, each fined $50, and given jail sentences ranging from 10 to 30 days. On July 18, 1940, in another mine of the same company, a man was caught with tobacco, papers, and matches in his possession and prosecuted by the State, convicted, fined $50, and given a suspended jail sentence of 10 days. During the first 6 months of 1940 this company disciplined five other men to the extent of 5 to 7 days lay-off for either smoking or possessing smoking materials while in the mine in violation of the State law.

12. Evidence[9/] that a spent match and five live matches were found in an Ayrshire pit after an explosion in which three men were injured, two of them fatally, was given at a fatal-accident inquiry at Kilmarnock Sheriff Court on November 1, 1939. Inquiry was made into the deaths of John Young Sharp, 34, and Andrew Haggerty, 39, who died in Kilmarnock infirmary from burns and shock following an explosion of gas in Shewalton No. 7 mine, Dreghorn, Aryshire, at 3:30 a.m. on July 27, 1939. A nurse in the infirmary stated that she found a cigarette end in Haggerty's waistcoat pocket, and an inspector of mines stated that a few feet from where the accident happened in the mine he found a burned match and five live matches. It was stated, also, that electric safety lamps were used in the section in which the men were working, a notice was posted prohibiting the taking of matches or tobacco into the section, and a system of searching the men before they entered the section to work was in effect. Evidence was given by the men who saw Haggerty immediately after the explosion to the effect that he told them that he had done it and that it was his fault; they understood this to mean that he had struck a match.

13. In August 1940 two men were burned as a result of a gas explosion in a Pennsylvania mine. The first statement of the victims was to the effect that the gas was ignited by an electric arc. Subsequently they admitted that they had been smoking and that this had caused the ignition. This mine is on a closed-light basis, and the acts of these two men not only violated the State law but jeopardized the lives of scores of coworkers.

As further evidence of the widespread violations of State mining laws prohibiting smoking in mines, a short time ago, while an official was making a trip through a large-capacity closed-light mine in Illinois known to give off considerable quantities of explosive gas a distinct odor of tobacco smoke was detected in the mine at three different places, although definite proof as to the identity of the guilty person or persons was not obtained. Although there was no ignition of gas with probable resultant loss of life, it was not the fault of the culprits, who were making their contribution toward a disaster.

9/ Colliery Guardian (London), November 10, 1939, Vol. 159, No. 4115, p. 698.

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CONCLUSIONS

The foregoing examples are but a few of the numerous instances in which fires or explosions have been initiated or suspected of having been initiated by smoking or smokers' materials; the number could easily be doubled or trebled, but it is believed that the foregoing examples are sufficient to indicate and emphasize some of the hazards incident to smoking underground. The matter is decidedly serious, inasmuch as four of the instances given occurred in coal mines in four States within the past year (October 1939 to October 1940). Smoking has no rightful place in any mine, gassy or non-gassy, coal or metal, as it has caused numerous mine fires as well as dozens of gas or black-powder ignitions in coal mines and at least a few in other mines.

Although the main responsibility for this type of violation of sane mining procedure rests squarely on the shoulders of the person who does the smoking (and in at least some instances mine officials, including fire bosses, are offenders) the supervisory force must bear a definite share of that burden of enforcing the no-smoking provisions of State laws or regulations or company rules. This enforcement is by no means easy, as some persons are inveterate smokers with a definite craving for smoking, and they devise ingenious methods for taking smoking materials into mines, irrespective of State or other regulations, search, or possible penalties. The usual methods of search are crude and perfunctory, both as to procedure and frequency, but even when the searching for smoking materials is fairly rigid, the smoker uses such subterfuges as hiding smoking materials in his lunch bucket or between pieces of bread in a sandwich or in his thermos bottle, supposedly filled with hot coffee, or in his shoes or socks, or in hidden pockets in his underwear.

One of the worst features of surreptitious smoking in mines is that the smoker usually tries to find some out-of-the-way place in which to smoke, such as a partly caved pillar region or an abandoned room or other place where usually there is an extra hazard of methane accumulations owing to difficulty in ventilating it. Moreover, the mine smoker is no more careful than his type in a forest or other out-of-the-way place, and very often he leaves behind him a burned match or unextinguished cigarette, which slowly ignites the surrounding combustibles, and the fire cannot be discovered easily because of its hidden location.

The coworkers of surreptitious smokers in coal mines also have a responsibility, which they are seldom inclined to assume for obvious reasons. While they must be credited with a certain kind of loyalty to their kind in shielding their erring coworkers, on the other hand it would appear that in a matter as serious as this they should not hesitate to take drastic action, at least to the extent of trying to enlist the aid of coworkers in restraining the smoker, even if they would not care to inform mine officials or legal authorities of the dangerous acts of the man who persists in smoking in a mine where smoking is forbidden.

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The callousness of the inveterate smoker is well-illustrated in an incident that took place in a coal-mining camp in Colorado, in which State and Federal inspectors and company officials emerged from an arduous inspection of a gassy mine to ascertain the cause of an explosion in which about 20 lives had been lost a few days before. On the particular day on which this episode occurred another gassy mine in that coal camp, unconnected with the one in which the explosion occurred, had been operated by the same company. As the officials came out of the mine in which the explosion had occurred they were told that the men who had entered the working mine were searched for smoking materials before they entered that morning and no smoking materials were found. However, one man, known to be reckless and obstinate and to like to smoke, was suspected of having smuggled smoking materials in some manner, and after he had been working at his place a few minutes he was forced to disrobe and smoking materials were found inside his socks. In this case, this man very evidently intended to smoke in this very gassy mine even though about 20 of his fellow townsmen had been killed in a gas explosion only a few days before and most of them were not yet buried. He was exposing himself and nearly 200 coworkers to a similar fate merely to gratify his smoking habit.

That the mining laws or regulations of the various States with respect to smoking have been and are being violated with impunity, and to an alarming extent, causing much needless loss of life, does not seem to be fully recognized or appreciated by either the mine employers or employees or even safety inspectors or State and other mine officials.

The prevalence of such violations of sane mining practice would seem to indicate that the mental attitude of the law breakers is that because one violation passed without apprehension and without disaster, similar future violations may be committed with the same complacency and false sense of security. However, the law of averages is inexorable, and sooner or later the offender is likely to suffer the dire consequences of his acts and probably will force to suffer with him many of his loyal, law-abiding friends and fellow workers.

It is hoped that this paper may be instrumental in helping to prevent further needless sacrifice of life through the foolish practice of smoking in mines; that it will help to bring about closer cooperation between employers and employees with respect to this as well as other matters of safety; that it will dissipate the idea that breaking the law is clever; and, finally, that it may tend to lighten the burdens of the employees, employers, State mine inspectors, and, incidentally, employees of the Bureau of Mines by preventing further mine disasters not only from this cause but from all causes.

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